Edison Group, Inc

Business Value in Virtualization

How consolidation on top-end/multiprocessor Intel® Xeon® processor-based platforms leads to an overall reduced administrative and operational TCO

For

Intel

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Executive Summary

You've already decided that deploying Intel®-based server virtualization is the most cost-effective consolidation pathway for your organization's data center. You may think that using low cost entry servers for virtualization is the best way to save money and improve ROI but you would be mistaken! In order to achieve the maximum benefit of this approach, it is important to examine how much additional cost-savings you will gain by choosing the higher-end performance processors and 4-way or larger SMP servers. By giving you the ability to more densely pack virtual machines on a single physical server, higher-end processors and larger SMP platforms give you the optimal benefits providing the best power efficiency, the highest density and more cost efficient virtualization and consolidation solutions.

When choosing the most cost-effective server platform for consolidating through virtualization, a top-end[1] dual-processor will save you as much as 32 percent per server instance over an equivalent entry-level server! For example, it costs $7,600 for a top-end entry-level dual-process server versus $5,100 for an entry-level dual-processor, a 49% cost increases yet you could run more than *twice* as many virtual machines on the former.

Savings through virtualization are more apparent when considering an operation's cost over three years. For example, it costs $78,487 for a top-end 4-way fully loaded server versus $55,018 for an entry-level equivalent server. However, higher-end processors offer the most cost-effective choice, with a savings of 77 percent per server instance over three year's time.

In addition the top-end dual core based processors provide significantly better power efficiency for consolidated environments providing 23-70% improved power savings. This is a critical purchase decision factor for data centers constrained by power and cooling limitations as the cost of adding additional data center space or power/cooling often dwarfs the server hardware costs.

[1] For purposes of this study top-end processors for any specific design refers to dual-core vs. single core models. More information is available in following sections. (Background Materials and Assumptions, Page 3)

Introduction: TCO/ROI Analysis

Information Technology (IT) organizations are increasingly implementing server virtualization as a solution to dramatically lower data center costs and increase competitive advantage. Improvements in distributed computing technology — particularly in operating system design — have made it feasible today to operate multiple server applications as "virtual machines" (VMs) within a single actual unit using Intel® Xeon® brand X86 processors. This Business Strategy Report examines the cost structure of virtual machines running on Intel ® Xeon® processor-based entry-level and top-end 4-way and 2-way server-based platforms.

Total Cost of Ownership (TCO) is defined as the cost of owning, operating, and maintaining a computer system. A successful TCO analysis should include all costs; this comprises the up-front costs of hardware and software, as well as the costs of installation, training, support, upgrades, and repairs. This report provides metrics and calculations that can be reused in your own Total Cost of Ownership analysis.

Consolidation through virtualization has played an important role in reducing the amount of hardware required to perform necessary computing tasks. The transition is made based on determining the value associated in migrating to a server that can host several virtual machines. This report quantifies the benefits of virtualization on server platforms utilizing top-end processors. It explains how cost-effective it is to select platforms offering a higher density of virtual servers per machine. Using the *highest-performing* Intel® processors, you can achieve this goal while simultaneously maintaining high levels of performance.

The benefits of deploying servers with top-end Intel® processors can be seen whether the server platform includes dual-processor or multi-processor architectures. For example, using top-end processors can effectively double the ratio of virtual to physical servers with only a 50 percent increase in energy consumption.

This report considers the economic impact of achieving a higher density of servers through virtualization by utilizing top-end Intel® Xeon® processors. Virtualization technologies translate into both time and money. For their investments in a virtualization platform, organizations often need help in making not only the technology case, but also the business case.

The server model in practice today is one server box, running one application. This report describes a model of creating a more efficient consolidated server model that can host multiple operating system and application instances on a single server box. Higher-end processors greatly increase the number of workloads that can be sustained in a data center. A key reason to virtualize server instances is to improve TCO/ROI. Our purpose is to demonstrate that the ROI/TCO advantage gained is greater with higher-performance processors.

This report should assist IT professionals in deploying or developing a strategy for consolidated enterprise servers. It should help them decide which virtualized platform best meets their needs by providing data on performance scalability between the most popular Intel®-based server types and processors.

Background Material and Assumptions

This report examines the business impact of increasing density during server consolidation. The Edison Group study report entitled "*Optimizing Virtualized Data Centers*[2]" demonstrates that utilizing top-end processors increases the number of virtual servers per physical server while increasing energy consumption by only 50 percent. In that study, Edison Group set out to measure the effect that higher-performance Intel®-based 2-way and 4-way servers would have on VM capacity, testing the premise that better platforms and top-end processors will result in greater consolidation capacity. Specifically, tests were designed to determine the ratio of processing cost to performance strictly in terms of capacity to reduce overall server hardware — for example, if a 20 percent higher-priced processor might yield 60 percent more VM capacity. The results established this to be the case.

Intel provides a series of CPUs with incremental performance advantages; this report applies the terms "entry-level" and "top-end" to refer to those with the lowest and highest overall performance capacity, respectively. The following chart summarized the relevant features of the servers used in the *Optimizing Virtualized Data Centers* mentioned above. For purposes of these studies, Entry-Level refers to Single-core models and Top-End refers to dual-core models of each processor category.

	Entry-Level DP	Top-End DP	Entry-Level MP	Top-End MP
# Processors Used	2	2	4	4
CPU Speed	2.8Ghz	2.8Ghz	3.16Ghz	3.0Ghz
CPU Cache Size	2MB	2MB	1MB	2MB
# Cores	1	2	1	2
FSB Freq	800Mhz	800Mhz	667MHz	800MHz

Table 1 - Test bed server specifications

In addition to significant financial advantages, higher-density servers reduce the time and risks involved in achieving the consolidation goals of increased reliability, scalability, and flexibility. Higher-density servers address the utilization issue and present strong business arguments.

[2] This paper can be accessed in the Edison Group document library at http://www.theedison.com/index.php/articles/175. (Registration is required.)

Leveraging Consolidated Computing

Thanks to more advanced technology, alternatives are now possible to the application-dedicated server model typically in use today. No longer is it necessary, for example, to have a server entirely dedicated to e-mail, or a web server, or shared database-driven application.

Server consolidation is not only feasible but is frequently highly desirable, particularly in enterprise environments. Reducing 100 physical servers to 50, for example, has obvious factors to recommend it in terms of space, maintenance, licensing, etc. Consolidating servers can also reduce the wasteful processing inefficiency of dedicated servers, which commonly operate at well under 20 percent processor utilization.

Compare and Contrast Intel Platforms

When Edison Group compared the effect on virtual machine density for the highest-volume Intel®-based server platform types (2-way and 4-way), as well as entry-level versus top-end Intel® processors supported on each platform, the approach taken was to replicate the common solutions IT managers are reportedly deploying when they virtualize and consolidate, and then to test the impact on the performance of targeted Intel®-based server platforms with different CPUs. The results provide an indicator of the performance scaling between Intel® server platforms and — within the same platform — of the entry-level versus top-end processors.

The following data and analysis detailed in the 'Optimized Virtualized Datacenters' report is used as the basis for the business value/TCO development. Specifically the VM Capacity metric is used to reflect the relative ability for one platform to run VM workloads vs the others tested. The actual power used during the testing and the number of VM's executed were used for the power cost and Windows licensing calculations.

	Entry-Level DP	Top-End DP	Entry-Level MP	Top-End MP
Number of VMs Run	4	7	7	17
CPU Utilization	63%	59%	62%	62%
System Avg Power (Watts)	291	441	650	929
VM Capacity	1.00	1.87	1.78	4.32
VM Headroom Capacity	0.59	1.10	1.04	2.54
VM Power Efficiency	1.00	1.23	0.80	1.35

Table 2 Utilization and Capacity

Key differentiating factors exist between 2-way and 4-way platforms. The current Intel®-based top-end processors have two cores per processor. This is like having two processors on one physical chip. This effectively doubles the number of processors in a server without increasing the supporting circuitry and numbers of sockets required.

For the purpose of this paper, we consider the following hardware configurations:

- Entry-level dual-processor machines with single-core processors
- High-end dual-processor machines with dual-core processors
- Entry-level multiprocessor machines with four single-core processors
- High-end multiprocessor machines with four dual-core processors

Platform Considerations

Key performance factors differentiate Intel 2-way from 4-way servers, as well as their associated entry-level from top-end processors. While performance is a key element in IT

platforms decisions, it is not the only one and is usually not the primary criterion for choosing a server. IT managers must consider the ROI or TCO of a system.

Reliability is particularly important in consolidation environments. Because more applications are being executed on a single physical server, the failure of any one server would have a broader impact within the data center and user base.

In a single-server instance, the number of *actual* physical machines is at least two in a high-reliability system. Due to the complexity involved in modeling the number of server instances (as opposed to the number of VMs and physical machines required), such a consideration is not included in our analysis.

Scalability is also important, so that the server can be upgraded with more and/or faster I/O devices and memory without requiring the purchase of additional servers. The operational efficiencies of provisioning and managing less servers is a key consideration in many data centers, where licensing cost efficiencies between platforms are also typically taken into account. The physical space and power used by the servers, too, is often a factor in data centers with limited space or power/cooling facilities.

Financial Summary

The real question you have to ask when buying a server with a entry-level processor is: what does it cost to run each virtual machine? The cost of each virtual machine is lower with respect to how densely you can load a given server. The costs per VM are highest with an entry-level, 2-way server, and are lowest on a 4-way, top-end server.

Cost factors are based on energy consumption, occupied space for servers, and virtual server licenses. Server costs are calculated in terms of capital costs and operational costs. Capital costs are the up-front expenses including the servers, VMware ESX Server licenses, VMware VirtualCenter, Windows 2003, and installation costs.

Operational costs (over a 3-year period) are calculated from server maintenance, VMware ESX Server maintenance, VMware VirtualCenter maintenance, energy costs, and space for housing these servers.

One starts to see savings from a server environment when consolidation of physical servers into virtual servers is a factor. Servers are far more powerful today and can literally do more. In fact, one physical machine can do the work of anywhere from four to eight servers. The key to success is to employ higher performance processors.

Performance is a key factor when determining the value propositions of choosing a multi-processor system. VMware ESX Server reduces TCO by creating a cost-effective environment that translates into lower technical support and training costs. Server consolidation re-appropriates idle resources and re-deploys them on new processes without incurring additional costs in hardware. The results? Greater operational efficiency, as demonstrated by the chart appearing later in this report, which shows the average savings for a typical computing environment achieved through virtualization models.

Consolidation of physical servers has gained industry acceptance as a means of lowering Total Cost of Ownership in your technology. Substantial benefits can be gained by reduced data center costs, faster provisioning, and more refined administrative management. With virtualization software running on Intel® Xeon® processors, businesses can effectively consolidate diverse operating processes and applications on less hardware.

Acceptance of virtualization is definitely on the rise. It's been reported that 90% of the Fortune 100 have begun implementing virtualization technology to consolidate their servers and that up to 1/3 of all business worldwide will do so in 2006.

This report examines the ROI you achieve from migrating to 2-way and 4-way multi-processing platforms. A move to top-end processors, larger cache, and increased memory all deliver better value by promoting consolidation of physical servers.

Intel® Xeon® processor-based servers promote consolidation of multiple applications onto 2-way processors. 4-way processors can support still greater workloads and more virtual

The following table (Table 3) illustrates cost reductions and TCO savings you can realize, on an individual instance basis, in a consolidated computing environment. The key metric introduced is the VM cost efficiency of the platform. This metric is a relative efficiency of using one Intel®-based platform over the other for any given set of VM workloads. For example, if you have applications that require the 100 units of VM computing capacity, then if you purchased entry 2-way servers if would cost you $2.8M for entry DP server (100 VM / 1 VM capacity x $28K per server) or you could use 4-way top-end platforms which would cost $1.82M ((100 VM / 4.32 VM capacity) x 78.5K) for a $1M and 55% 3 yr savings!

While we recognize that every company's costs for space, power & cooling, platform costs, software licensing and operator overhead are slightly different we expect that the overall cost efficiency and TCO of the platforms will be maintained for the broadest set of users. It is highly recommend the readers use the chart and costs below as a template in developing their own specific TCO analysis.

Capital Costs	**Entry-Level DP**	**Top-End DP**	**Entry-Level MP**	**Top-End MP**
Servers	$ 5,100	$ 7,600	$ 15,400	$ 27,500
Additional Data Center Costs	$ 500	$ 500	$ 500	$ 500
VMware VMware Virtual Infrastructure Node	$ 5,000	$ 5,000	$ 10,000	$ 10,000
Windows Licensing	$ 4,000	$ 7,000	$ 7,000	$ 17,000
Installation	$ 780	$ 780	$ 780	$ 780
3 Year VMware Virtual Infrastructure Node with Maintenance	$ 5,253	$ 5,253	$ 10,506	$ 10,506
3 Year Operator/Admin	$ 4,500	$ 4,500	$ 4,500	$ 4,500
3 Year Energy	$ 1,829	$ 2,596	$ 4,100	$ 5,469
3 Year Datacenter Space	$ 1,116	$ 1,116	$ 2,232	$ 2,232
Total Costs	**$ 28,078**	**$ 34,345**	**$ 55,018**	**$ 78,487**
VM Capacity	1	1.87	1.71	4.32
VM Cost Efficiency	**1.00**	**1.53**	**0.87**	**1.55**

Table 3 = VM Cost Efficiency

Hardware and Software Costs

Server Costs

Consolidation is a key component in reducing your overall expenditures for server costs. Savings mount in proportion to the number of virtual machines that you can effectively load onto each physical server. That number of VMs rises cost-effectively with respect to the capabilities of your processor, such that a top-end processor can house more virtual machines than an entry-level one.

We are primarily discussing capital and operational costs. The table above shows that, as the price of the servers increase from entry-level to high-end configurations, your cost per VM actually decreases. Higher-end processor can accommodate a greater number of VMs, resulting in better consolidation of physical servers into one machine—making the better processor the more cost-effective choice in terms of cutting costs associated with energy, space, maintenance, and licensing. Even though you pay more for one higher-end box, you can actually house a greater number of VMs at a reduced price point.

The server pricing used in this analysis was based upon the test servers used in the Edison Group study report entitled "*Optimizing Virtualized Data Centers.*" The servers selected were from Dell and HP and were configured in a manner similar to what Edison Group ran the tests on, but matched for features and realism between the two brands. We then averaged the prices of the systems. We used Web pricing current at the time of report creation: available models, features and pricing will undoubtedly be subject to change. An additional cost of $500 per machine is included in the calculations to account for peripherals and cables not accounted for in the average system price. The features for the systems were:

- Entry-level DP
  - Dell - PowerEdge 2850 and HP - DL380
  - Xeon® 3.0 GHz 2 MB cache, 800 MHz FSB
  - 4 GB DDR2 200 MHz single-ranked DIMMS (4X1GB)
  - Rack configured
  - No OS installed
  - Drives attached to embedded RAID controller
  - Riser for PCI-e cards
  - three 73 GB 15K Ultra 320 SCSI drives
  - Dual on-board 1 GB NICS

- 24X IDE CD-RW/DVD ROM drive
- No floppy, monitor, keyboard, etc.
- Redundant power supply
- Electronic documentation
- 3-year service and support
- No installation services

- Top-end DP
  - Dell - PowerEdge 2850 and HP DL380
  - Dual-core Intel® Xeon® Processor 2X2 MB cache, 2.8 GHz, 800 MHz FSB
  - All other features the same as for entry-level
- Entry level MP
  - Dell PowerEdge 6850 HP DL580
  - 4 Intel® Xeon® processor at 3.16 GHz/1 MB cache
  - 8 GB DDR2 400 MHZ RAM (4X2GB) (HP had additional memory boards installed and memory installed 1 DIMM per board as in our lab. Dell did not offer the feature.)
  - Other features the same as or equivalent to those on the DP boxes (same drives, etc.)
- Top-end MP
  - Dell PowerEdge 6850 and HP DL580
  - 4 dual-core Intel® Xeon® processor 7040 3.0 GHz 2X2MB, 667 FSB
  - Everything else the same as entry-level multiprocessor

VMware Costs

The costs for virtualization services are based upon VMware ESX Server. We selected VMware ESX for the benchmark study because it is the most popular virtualization engine on the market today. ESX was chosen specifically because it required lower overhead on the server than other solutions which required an underlying operating system be installed, such as VMware Server.

The pricing we are using is for a bundled package from VMware called Virtual Infrastructure Node, which consists of four components: VMware ESX Server, VMware VirtualCenter Agent, VMware Virtual SMP, and VMware VMotion. Two of these extra components (VirtualCenter Agent and VMotion) work with the all-but-mandatory VMware

VirtualCenter Server[3] in providing the administrative, monitoring, and reliability advantages offered by VMware. The third, Virtual SMP, makes it possible for a single virtual machine to span multiple physical processors.

Windows Licensing Costs

Microsoft public pricing for the Windows 2003 Enterprise Edition is $3995 which allows for up to 4 guest operating systems licenses or $1000 per windows-based VM. The costs used in this analysis are based on the actual number of VMs executed by each platform in the original benchmarking tests multiplied by $1000. They do not actually impact the overall VM Cost Efficiency based on the approach used but are included for completeness.

Operations Costs

Datacenter operations costs are ultimately as large or even a larger factor in TCO as the acquisition costs for the hardware and software. Operations costs include:

- Energy Costs
- Installation or Deployment costs
- Space utilization (Real Estate)
- Hardware maintenance
- Additional Benefits
- Administrators and Operators

The focus of this study is on calculating TCO factors that can be directly attributed to the value of greater virtual machine density per physical server offered by Intel® Xeon® processor-based top-end processor based platforms. The operations areas that can be directly attributed to VM include: Energy Costs, Installation Costs, Space Utilization, Hardware Maintenance and Additional Benefits.

The cost savings that could be attributed to administrators and operators are not treated as a separate item in our calculations, except where they're included in one of the other operations costs areas. We discuss how to address the potential savings opportunities due to administrator and operator costs below.

Energy Costs

Energy costs are a major concern in the twenty-first century data center. This is especially the case as an increased density of physical servers not only increases the electrical

[3] VMware Virtual Center Server is a cost in our model, though only one license is usually required per network.

consumption by servers in the data center, but also increases the amount of heat that needs to be dissipated. The Edison Group study results showed that test servers with entry-level dual processors consume 250 watts, while test servers with top-end processors consume 455 watts.[4] Our calculations show that the combined costs of server and cooling electrical use demonstrate an approximate savings of 15 percent to 20 percent per virtual machine in electrical consumption when the high-end processors are used instead of their entry-level counterparts.

Data Center Space Costs

Top-end servers can literally earn their keep by making it possible to occupy only half as much space as entry-level servers. Virtualization makes it possible for servers with high-end processors to do the same amount of work as twice as many physical servers. If there are 40 servers per rack, with 10 racks per square foot, costs (on average) are $62/sq. ft. each month; cutting that in half could reduce monthly bills by $31/sq. ft.

Installation Costs

Considering that an IT tech receives about $65/hour to install a server—and that each installation project requires approximately 12 hours to install—it is plain to see how virtualization plays a very important part in reducing these costs.

Additional Benefits

Virtualization presents several additional benefits to your overall TCO. Consolidating your server environment can proceed very quickly due to "cookie cutter" virtual machine templates that make provisioning new servers a fast and easy process.

Consolidating your environment not only reduces the number of physical machines, but also *lowers your operational complexity*, ongoing maintenance, and overall operational costs. Downtime and the need for service are reduced because you have fewer machines that can break.

Less complex Datacenter Design Issues

Your overall datacenter design is literally streamlined. Everything from the number of electrical, data and storage network cables, through the number of sockets on Power Distribution Units, Ethernet and Fiber Channel Switches is reduced in direct proportion to the number of physical servers upon which Virtual Machines are running. Other savings can include the number of equipment cabinets, cable races and the numerous sundry expenses inherent in datacenter operation. We've assigned an estimate of the average cost of these items in our calculations.

[4] Power utilization curves were essentially the same for 2-way and 4-way servers.

Additionally, your cooling requirements will decrease proportionally with the number of physical servers in your environment. Simpler cooling systems may also be sufficient due to your greatly reduced number of hardware systems.

Avoided Downtime from Human Error

Additional benefits also include reduced downtime you might experience as a result of *human error*. Mistakes made with a physical server require reinstallation of ***everything*** for that server—a process that can take several days. A high-density virtualized environment has fewer components that can succumb to human error.

The greater the number of virtual machines, the better your efficiency. Your consolidation efforts will reduce downtime. Fewer machines require fewer peripherals and accessories to accomplish the same computing tasks.

Administration and Operator Costs

A Datacenter TCO analysis is not complete without taking into account administrative and operator costs. The numerous studies on the savings possible from server consolidation all speak to these savings, though in most cases these savings are aimed at installation or deployment and maintenance: items we consider under other headings. The remaining administrative overhead tasks focus on four distinct task areas:

1. Software Tasks — include patches, updates, and tuning
2. Data-oriented Tasks — include items such as backup and restore operations
3. Application Tasks – include compiling, configuring, tuning, and updating
4. Monitoring – includes server hardware, operating systems, and applications

Of these, monitoring will be the most directly influenced by virtual server density. For example if one is monitoring only one-forth the devices, cost savings accrue from fewer monitoring software licenses as well as reduced staff doing the monitoring. As there is a wide variety of products and licensing policies, we are not including a cost factor for licensing, though the uniform factor assigned to "Additional Datacenter Savings" could be adjusted to reflect these licensing costs in your own calculations. Similarly, the actual savings in monitoring operator costs is still apparently more theoretical than measured at this time (see below). We have therefore not assigned a per virtual machine TCO value to this item.

There will undoubtedly be time savings related to data-oriented task costs such as for backup and restore. These savings are influenced by storage architecture decisions and other factors that are not directly attributable to the number of physical servers being backed up. Similarly, Application Tasks are dependent upon internal development process and other factors, and are also not directly correlated to virtual machine density. In the area of Software Tasks, administrative savings when rolling out updates are possible due to

reduced or eliminated downtime and similar factors, but these savings cannot be correlated to the number of virtual machines running on a particular physical device.

A recently published study by Gartner Group[5] points out that even though 31% of the respondents to the survey reported upon expected savings in staffing; only 25% of those who had already implemented server consolidation projects had actually saved headcount (resulting in hard dollars). The report also states that while there are staffing effects from consolidation, the people affected are often moved to new roles, addressing project backlogs or onto new projects lowering the need to hire additional staff.

It is accepted in the industry that consolidation through virtualization can affect administrator and operator costs. There are published predictions that the number of people required for monitoring and administrating computer systems in the datacenter may decline by as much as 50% in the next two decades. Consolidation is only one of many factors contributing to these Human Resource savings. Our research into administrator and operator costs includes some components of operations savings in its computations but due to varying factors and different organizational policies, system architectures, and other issues not all factors can be included. Our conclusion is that these values are unique to each individual datacenter consolidation plan and enterprise. When you refer to our findings in architecting your data center, you should apply your own savings factors based upon your organizations policies, goals, and expectations.

For the purposes of our TCO development it is assumed that the operator cost for a server are independent of the platform type or processor type and is effectively the cost of managing the physical server and managing VMware ESX updates. The $4500 per server is based on an operator salary of $75,000 per year who supports 50 physical servers over a 3 year period.

[5] "Server Consolidation Is Still a Major Goal, but Not Just for Cost Cutting" ©March 2005, John R. Phelps. This study can be found on-line but requires either purchase from Gartner or registering at a commercial site that has licensed the study.

Conclusions

Higher-density virtual machine platforms make it possible to conserve space, maintain functionality, and keep your performance constant—while at the same time lower costs of management, cooling, and power. TCO benefits make it possible to create an environment with smaller computing footprints while losing nothing in the transition.

In the case of both two-way and four-way servers, switching from an entry-level to a top-end environment effectively doubles the number of VMs the server is capable of running. Furthermore, this doubled capacity for VMs comes with no corresponding increase in CPU utilization. The top-end processor based platforms offer 53-77% better TCO over a 3 year period than their entry-level equivalents. Comparing the 2-way top-end vs. 4-way top-end platforms shows equivalent cost efficiency (within 1.5%). Managers deciding which platform to use will need to consider other platform capabilities based on their needs; for example the 4-way would provide better racked server density, 8% more power efficiency, over 2X the unused CPU headroom capacity and support more than twice the number of VM's in one physical server but requires a much higher initial procurement cost.

Overall TCO is based on the optimization of virtualized data centers with Intel® CPUs, since switching to the top-end technology effectively doubles the workload capacity at a fraction of the costs related to hardware, maintenance, facility space, electricity, and cooling.

When designing a datacenter that will consolidate servers through virtualization, Total Cost of Ownership is a major consideration. Our research shows that selecting server platforms that offer the highest virtual machine density provide the greatest TCO savings.